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U.S. Gasoline Demand: Will the Decline Continue

Institute for Defense Analyses
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R. William Thomas
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PROGRAM ANALYSIS DIVISION

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This study uses an empirical economic model to study the recent decline in U. S. gasoline demand. The model's predictions are compared to actual experience over 1978-80 and projections of future demand are made through 1990.

The model was developed for the Energy Information Administration by James Sweeney. It predicts the stock of automobiles, average fuel efficiency, and vehicle miles driven. These forecasts all combined to yield estimates of gasoline consumption. The model forecasts unleaded gasoline, leaded gasoline, and diesel usage separately for cars, trucks, and other users.

Results of the simulation make clear that the recent decline is only the short-term response to recent price increases. Further substantive declines can be expected even if gasoline prices only increase with the general cost of living.

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EXECUTIVE SUMMARY

A. INTRODUCTION

The recent decline in U.S. gasoline consumption surprised many analysts by its size and persistence. Economic models of gasoline demand have predicted that demand would decline if the price were to increase sufficiently. However, until the recent episode, increases in other determinants of demand tended to overwhelm the effects of price increases and demand continued to rise through 1978. This study uses an empirical economic model of gasoline demand to examine the decline. The model's predictions are compared to actual data for 1978-80 to confirm the validity of the model's structure; then projections are made through 1990 to establish whether a continued decline in gasoline demand can be expected.

The decline in total gasoline consumption was accompanied not only by a decline in unleaded gasoline consumption but also by a lower fraction of unleaded gasoline usage than expected which eliminated any problem in meeting unleaded demand for the U.S. petroleum industry. Since shortages of unleaded gasoline might lead to increased misfueling of cars equipped with catalytic converters, the plentiful supply of unleaded gasoline removed at least one concern for those involved in monitoring efforts to reduce automobile emissions. The modern economic theory of gasoline demand emphasizes the distinction between short-run and long-run effects of an increase in the price of gasoline. In the short run, consumers respond to a price increase by lower utilization of a fixed stock of cars; in the long run, however, substitution of vehicles with

higher fuel efficiency reduces the impact of a higher gasoline price on the cost of operating the vehicle. Thus, the long-run adjustment may involve a return toward the old utilization pattern.

B. METHODOLOGY

The methodology of this study uses the Energy Information Administration (EIA) Motor Gasoline Model developed for the EIA by Professor James Sweeney of Stanford University. The model makes use of annual data on the stock of vehicles, the fuel efficiency of each vehicle type and vintage (year of manufacture), and patterns of utilization over the life of each vehicle. A behavioral economic model is used to predict total vehicle miles travelled and new car sales as a function of consumer income, prices of fuels and vehicles, and other variables. Gasoline consumption is determined by dividing total vehicle miles travelled by the average efficiency of the car fleet. Another empirical model developed by Wharton Econometric Forecasting Associates (WEFA) was used to check the results of the EIA/Sweeney Model. The Wharton Motor Vehicle Demand Model was developed for the Department of Transportation for general analyses of the U.S. automobile market. The model is capable of generating gasoline consumption forecasts; its method is similar to Sweeney's, although implementations differ in detail.

C. RESULTS OF THE ANALYSIS

Simulation of the EIA/Sweeney Model showed that, once actual gasoline prices over 1978-80 were used, the model's predictions were fairly accurate. Examination of the differences between forecast and actual results showed that the residual model error could be attributed to errors in predicting the mix of new car sales in 1979 and 1980.

As supplied to IDA, the model consistently predicted higher fractions of unleaded gasoline usage than were observed in the actual data. A review of the model's data and assumptions traced this to several factors. First, the model's assumed scrappage rates were excessive; older vehicles were being retired too rapidly. Second, the proportion of trucks assumed to use unleaded gasoline was too high. Third, the data on which utilization patterns were based were outdated; recent results from the Nationwide Personal Transportation Survey were substituted. Once these corrections were made, the model's unleaded forecast closely matched actual data.

D. LONG-TERM RESPONSE TO PRICE INCREASES

A long-term simulation of the model was performed. This analysis showed that the 1978-80 decline was only a partial response to the current level of gasoline prices. Even if gasoline prices increase only with the rate of general inflation in the next ten years, demand will continue to decline as more and more low fuel efficiency vehicles are replaced with newer models. 1990 gasoline consumption is estimated at 5.5 million barrels per day, as compared with 6.6 million barrels per day in 1980 and 7.4 million barrels per day in 1978.

Since virtually all of the 1990 demand would be for unleaded gasoline (assuming no change in emission control technology), continued investments in new refinery facilities will very likely be required to meet even this lower demand level. However, this issue is beyond the scope of this paper.

Chapter I

INTRODUCTION

In a 1978 publication,[1] the U.S. Department of Energy projected gasoline consumption to range from 7.58 million barrels per day to 7.96 million barrels per day in 1980, depending upon the level of economic activity and the extent of the improvement in fuel efficiency of the automobile fleet. The range of variation reflected different assumptions for the level of general economic activity but did not address possible variations in retail motor gasoline prices. In fact, the study stated "...retail motor gasoline prices were assumed to remain constant in real terms over the forecast period. This, in fact, has been the case for the last four years."[2] The study went on to conclude that "...with 1980 consumption of motor gasoline at these projected levels, the refining industry will have to take certain actions to increase supply."[3] In particular, the study addressed the issue of octane-increasing additives--

> Under authority of the Clean Air Act the EPA has ruled that lead must be phased out of use. However, as a result of the specific appeals by refiners, the EPA has somewhat relaxed its schedule at different points in time while maintaining the end schedule target of .5 grams of lead per gallon by October, 1979....Thus, while

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[1] E. Tukenmez, R. Farmer, H. McDaniel, C. Everett, H. Walton, *1980 Motor Gasoline Supply and Demand*, DOE/EIA-0102/32, Energy Information Administration, Department of Energy, December, 1978.

[2] *Idem.*, page 2.

[3] *Idem.*, page 3.

> the EPA is expected to permit lead to be added to the clear...gasoline pool at the rate of about 1.2 grams per gallon through most of 1979, the industry will be required to reduce that level to about 0.5 grams per gallon by October. This action puts pressure on downstream refinery units which make high octane clear pool gasoline. The estimated effect of this phase-down is a reduction of possible gasoline output by about 500,000 barrels per day in 1980.[1]

A related question is the mix of unleaded and leaded gasoline demanded by the public. Given the necessity of investing new capital to produce additional unleaded gasoline, a rapid increase in demand for unleaded gasoline may create shortages in local markets. This increases the likelihood that some motorists may misfuel their vehicles with leaded gasoline.[2] The authors of the 1978 DOE report forecasted a mix of 50 percent unleaded gasoline in 1980.[3]

In May of 1980, the U.S. Department of Energy published its short-term energy outlook. In this analysis motor gasoline demand is projected to be 6.61 million barrels per day in 1980. "The outlook for the second quarter of 1981 for the base case calls for continuation of decline in motor gasoline consumption. Due to high prices, decreased economic activity, and increases in average fleet fuel efficiency, motor gasoline use is expected to decrease by six percent below 1979 levels, to an annual average of 6.6 million barrels per day in 1980.[4]

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[1] *Ibid.*

[2] See D. Dacy, "Interaction of Misfueling Due to Price Differential and and Shortage," and P. Cutchis and R.C. Oliver, "Misfueling Estimates and Air Quality Effects" in P. Cutchis, *et al., Papers Related to Gasoline Supply Misfueling, and Environmental Air Quality for the Summer of 1979* IDA Paper P-1445, The Institute for Defense Analyses, Arlington, VA:, October, 1979.

[3] Tukenmez, *et al., op. cit.*, page 29.

[4] Short-term Analysis Division, *Short-Term Energy Outlook,* DOE/EIA-0202/3, Energy Information Administration, Department of Energy, May, 1980, page 13.

In addition, the proportion of unleaded to total gasoline demand is 46 percent as compared to the predicted 50 percent.[1] In volume terms, this is a change from 3.98 million barrels per day to 3.05 million barrels per day, a decrease of 21 percent. This lower volume of unleaded gasoline production converted what could have been an extremely tight supply situation to a glut of unleaded gasoline.

Thus, in a year and a half, the major analytic agency of the Department of Energy revised downward its forecast for 1980 gasoline consumption by one million barrels per day, a decrease of nearly 14 percent.[2] The reasons for the decrease in current gasoline consumption are the subject of this paper.

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[1] *Weekly Petroleum Status Report*, Energy Information Administration, October 31, 1980, page 33.

[2] Interim revisions also were made between 1978 and 1980. EIA forecasts are updated at least annually.

Chapter II

ECONOMIC MODELS OF GASOLINE DEMAND

The demand for gasoline in the U.S. is derived from its role as a major motor fuel input in the production of transportation services. About 70 percent of total gasoline consumption is by passenger cars, with the remaining 30 percent accounted for by privately owned light trucks and vans, commercial light trucks, heavy trucks, and buses.[1] Considering only noncommercial use of gasoline, more than one-half is accounted for by urban short-distance travel, primarily commuting to and from work.[2]

Early research efforts failed to consider the fact that gasoline is an intermediate input in the production of transportation services.[3] Rather, it was treated in a manner similar to any other consumer good. An example of this approach is the study by Houthakker, Verleger and Sheehan.[4] This study estimated gasoline demand as a function of personal income, price, and lagged consumption. The authors used data for individual states to estimate the relationship. While the

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[1] Federal Highway Administration, Department of Transportation, *Highway Statistics*, Washington, D.C., 1978.

[2] Federal Highway Administration, Department of Transportation, *Nationwide Personal Transportation Study*, Report #7, April, 1972.

[3] An excellent survey of research in this area is Burke K. Burright and John H. Enns, *Econometric Models of the Demand for Motor Fuel*, R-1561-NSF/FEA, The Rand Corporation, Santa Monica, CA:, 1975.

[4] H.S. Houthakker, P. Verleger, and D. Sheehan, "Dynamic Demand Analysis for Gasoline and Residential Electricity," *American Journal of Agricultural Economics*, Volume 56, No. 2, (May, 1974).

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results were interesting (especially those that indicated that gasoline price elasticity varies by region), the flawed conceptual structure of the model reduces its usefulness for policy.

The modern theory begins with the demand for transportation services

$$T = T\ (Y,\ P_T/P_c)\ .$$

In its most general form, demand (T) is related to income (Y) and to the price of transportation services (P_T) relative to the composite price of other goods and services (P_c).

In studies of automobile use, demand for transportation services is measured by vehicle miles travelled by car

$$VM^d = VM^d\ (P_m,\ Y,\ X)$$

where VM is vehicle miles travelled per year, P_m is cost per mile, Y is income, and X represents other variables thought to influence mileage. Cost per mile can be expressed as the sum of fixed cost and variable costs (per mile)

$$P_m = \frac{TC}{miles} = \frac{FC}{miles} + \frac{VC}{miles}\ .$$

One of the variable costs is gasoline purchase. Then, denoting by VC* all other variable costs other than gasoline, we have

$$P_m = \frac{FC}{miles} + \frac{VC^*}{miles} + \frac{P_g G}{miles}\ .$$

Differentiating with respect to the price of gasoline, we obtain

$$\frac{\partial P_m}{\partial P_g} = \emptyset + \emptyset + \frac{1}{E} = \frac{1}{E}$$

where E is efficiency (miles per gallon). Although other fixed and variable costs might dominate in determining the

average price per mile, the above result demonstrates that the marginal impact of a change in gasoline prices on the price of automobile services is inversely related to the efficiency of the vehicle.

An increase in the price of gasoline relative to the price of capital and labor will induce substitution of the latter inputs for the former. An example of the forced substitution of labor for gasoline is the 55 mile per hour restriction, which economizes on fuel consumption at the expense of greater driving time for a given distance. However, more important to this analysis is the substitution of fuel efficient vehicles for less efficient ones.

In the short run, an increase in the price of gasoline increases the cost per mile of transportation by car. With the car population fixed, the only adjustments possible are (1) a reduction in total transportation demand as a result of the increase in cost, (2) in multi-car households, increased use of the more fuel efficient vehicle, or (3) substitution of other modes of transportation for car travel. In the long run, however, substitution of vehicles with high fuel efficiency allows the impact of fuel cost increases to be negated. Thus, one would expect the initial sharp reduction in transportation demand to gradually wither, as the cost per mile travelled moves back toward its former level. However, gasoline consumption will be permanently lowered.

The empirical models of gasoline demand used in this study embody elements of the theory presented above. Further extensions of this theoretical framework would determine car ownership and usage patterns in the larger context of total transportation demand.

Chapter III

METHODOLOGY

Most analysts relate the decline in gasoline consumption to the significant increase in real gasoline prices occasioned by OPEC's marked increases in crude oil prices over the period. During the year and one-half which elapsed between the publication of the first analysis and the second, the price of gasoline in nominal terms nearly doubled, rising from 66 cents per gallon to $1.25 per gallon.[1] The impact of this change was outside the bounds of assumptions made in the first Energy Department report. Can, in fact, the decline in gasoline consumption be related directly to this increase in price, or are other factors at work? One example of the latter was the decline in economic activity in 1980, which was not anticipated in the 1978 Energy Information Administration (EIA) study. This exercise is designed to explore the reasons for declining gasoline consumption in 1979 and 1980 and to relate the significance of price changes to other factors associated with the determination of consumption activity.

The methodology of this analysis makes use of two leading economic models of motor gasoline demand to illustrate the impact on gasoline consumption of price changes and other changes in economic variables. The first of these is the Energy Information Administration Motor Gasoline Model,[2]

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[1]"Lundberg Letter," various issues.

[2]T.H. Morlan, D.J. Gantzer, and F. Emerson, "Forecasting Auto Fuel-Demand; Latest Development at the Energy Information Administration," Mimeograph, Office of Energy Use Analysis, Energy Information Administration, Department of Energy, April 1980.

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developed for the Department of Energy by Professor James Sweeney of Stanford University. Professor Sweeney's original gasoline demand model was developed while he served on the staff of the Federal Energy Agency. His latest version, which was completed in the Spring of 1980, represents an extension and elaboration of his original work. The model is complex and detailed; it makes use of annual data on the stock of vehicles and of new car sales which represent additions to the fleet of vehicles. It couples this information with detailed information on the gasoline efficiency of these vehicle vintages and with information on the utilization of vehicles. New car sales and utilization are a function of general economic activity, the price of automobiles, the price of gasoline and other variables. The model provides an ideal vehicle to trace through the effects of gasoline price changes on gasoline consumption by elaborating the detailed effects operating in each of the above areas.

Since analysis of this sort may be thought to be conditioned by a single author's particular view of the economic process, Appendix C presents results derived using the Wharton Motor Vehicle Demand Model.[2] This model was developed for the Department of Transportation in order to make predictions on the number of cars in the American fleet, and on their utilization and associated gasoline consumption. Although its purposes differ somewhat from that of the Sweeney model, it provides comparable detail in predictions of gasoline consumption and automobile fleet. The use of two models rather than one will provide an important check on the internal consistency of the analytic effort, and a collaboration of the impacts of different factors, including gasoline prices, on gasoline demand.

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[1] *User's Guide to the Wharton EFA Motor Vehicle Demand Model*, Wharton Econometric Forecasting Associates, Philadelphia, PA:, n.d.

Both models use an automobile stock inventory approach to prediction of gasoline consumption. Basically, gasoline consumption is forecasted by (1) predicting the number of registered vehicles (classed by their size and origin), (2) predicting the on-road fuel efficiency of each class of vehicle, and (3) predicting the average miles driven per year per vehicle class. Annual gasoline consumption per class is then determined by multiplying the number of vehicles by their rate of utilization and dividing by fuel efficiency. While this approach might be used for all vehicles together, model developers believe that disaggregating the vehicle stock into classes improves the accuracy of the forecast. More importantly, the use of different size classes allows the modeller to capture the dynamic effects of an increase in gasoline prices on the composition of the automobile fleet.

We may represent the above calculation by

$$G \equiv \sum_{i=1}^{s} (N_i \cdot V_i)/E_i \qquad (1)$$

where G is an annual gasoline demand, N_i is the number of vehicles of class i, V_i is the average miles travelled per vehicle and E_i is the on-road fuel efficiency for vehicles in class i. The summation is over the s vehicle classes.

The above identity transforms the problem of predicting gasoline consumption to one of predicting the values of the variables which enter equation (1). N_i, the number of vehicles in calss i, is given by

$$N = N_{-1} + S - D \qquad (2)$$

where N_{-1} represents last year's stock of vehicles, S is current sales, and D is scrappage of existing vehicles. The i subscript has been dropped for clarity. New car sales are predicted as a function of income, automobile prices,

gasoline prices, and the unemployment rate. The formulation is a standard stock-adjustment model. The actual stock of cars is adjusted toward the target desired stock; the latter is a function of the independent variables of the equation. Adjustment is not complete within a single year; the rate of adjustment is determined statistically along with the other parameters of the equation.

Scrappage is a function of age and utilization. Basic scrappage rates are estimated from historical surveys of vehicle ownership and retention patterns; these rates are adjusted upward or downward depending upon the forecast utilization this year.

Efficiency of old cars is estimated based on EPA mileage ratings, which are adjusted downward to approximate actual on-road mileage figures. Efficiency of new cars is forecasted based on fuel price and technical trends. The average fleet efficiency is a harmonic weighted average of the efficiencies of models of different vintage.

Chapter IV

RESULTS OF THE ANALYSIS

A. THE EXPERIMENTAL DESIGN

Given the factors associated with current gasoline consumption (the size of the automobile fleet, utilization, and fuel efficiency), the analysis performed by IDA was designed to use the EIA Motor Gasoline Model to indicate the relative importance of gasoline price changes to changes in the above variables. That is, given that the current decline in gasoline consumption is related to the increase in gasoline price (which few analysts would dispute), is that effect felt mainly through decreased new car sales? Or is it attributable to either (1) lower utilization of vehicles or (2) people choosing very fuel efficient vehicles as they replace their old cars with new ones?

A secondary question deals with the ability of the model to capture the changes in gasoline consumption which have been observed. If the model is unable to predict *ex post* the sort of change which as been observed, we should have little confidence in the decomposition of the effects of the change in price produced using the model. Thus, the first question to be addressed is whether the model can replicate the decrease in consumption between 1978 and 1980.

B. COMPARISON OF ACTUAL AND EX POST FORECAST RESULTS

Table 1 compares the actual data on gasoline consumption for 1978-1980[1] with that forecast by the EIA/Sweeney Motor Gasoline Model under different assumptions. Column 1 is the actual data; one notes declines of 5.1 percent in 1979 and 10.8 percent in 1980, compared with 1978 consumption. Of course, the 1979 consumption figure is biased downward by the restricted availability of gasoline during the Spring and Summer of 1979; the extent of this bias is unknown, but some indication of its magnitude is available by comparing the model forecasts for 1979 with the actual figure.

Table 1. ACTUAL AND FORECAST GASOLINE CONSUMPTION

Year	Actual Data	Forecast Using EIA Model	
		1978 Prices	Actual Prices
1978	7,412	7,354	7,350
1979	7,031	7,109	6,928
1980	6,610[1]	6,814	6,350

[1]Estimated based on data for the first half of 1980.

Note that the 1979 forecast value using a real gasoline price (after adjusting for general inflation) equal to 1978 is only one percent higher than the actual figure, and that the 1980 forecast (using actual current prices) is six percent below the estimate for 1980. The model seems to exaggerate

[1]Actual data for 1978 and 1979 as reported in *Weekly Petroleum Status Report*, Energy Information Administration, Department of Energy. The 1980 figure is based on data for the first half of 1980, expressed as a seasonally adjusted annual rate. The Sweeney model was estimated using Federal Highway Administration data on gasoline consumption. These data diverge somewhat from the EIA gasoline data.

the effects of price changes. The nature of this bias will be explored in more detail later in this paper. However, the results for the model are not severely at variance with reality, and give some confidence that the model may be used to measure effects of different variables on gasoline consumption.

C. SOURCES OF ERROR - AGGREGATE GASOLINE RESULTS

Table 2 elaborates on the sources of error associated with the EIA Model forecasts. Column 1 of Table 2 repeats the information presented in the second column of Table 1. It shows the model forecast when the gasoline price is held to the 1978 level of approximately 75 cents per gallon. Column 2 presents the revised model forecast when prices are set to their actual level for 1979 and 1980. The model predictions are below the actual values by two to four percent.

Column 3 reveals the effect of forcing the model to use actual data on the number and composition of automobile registrations in 1979-1980. It is clear that errors in predicting the number and type of cars in use are the chief source of error. Closer inspection of the results shows that the model exaggerates both the extent in decline of new car sales and the degree to which buyers will select high mileage vehicles to replace their old cars. As a result, the total number of cars is underpredicted by 1,200,000 vehicles in 1979 and 1,800,000 in 1980.

By contrast, substituting actual data for the model's forecast values for new car fuel efficiency and average vehicle miles travelled makes little difference. The model is extremely accurate in forecasting average efficiency; the error in total vehicle miles travelled is largely associated with the error in predicting the number of vehicles.

Table 2. FORECASTS OF GASOLINE DEMAND

Year	(1) Using 1978 Gasoline Prices		(2) Using Actual Gasoline Prices		(3) After Adj. For New Car Sales		(4) After Adj. For Efficiency		(5) After Adj. For Utilization		(6) Gasoline Demand
	Pred.	Error	Pred.	Error	Pred.	Error	Pred.	Error	Pred.	Error	Actual
1978	7,354	-58	7,350	-62	7,505	95	7,503	91	7,425	13	7,412
1979	7,109	78	6,928	-103	7,207	176	7,191	106	7,081	50	7,031
1980	6,814	204	6,350	-260	6,715	105	6,677	67	6,659	49	6,610

Source: *Weekly Petroleum Status Report*, Energy Information Administration, Department of Energy.

Chapter V

COMPOSITION OF FUEL DEMAND

Because the catalytic converters used in most cars since 1976 are subject to contamination by lead, vehicles so equipped are required to use unleaded fuel. One of the more serious causes of misfueling is a scarcity of unleaded fuel; hence the EPA has taken steps to ensure an adequate supply of unleaded fuel for vehicles which require it.[1] Since the average life of an automobile is about ten years, the percentage of the automobile fleet which uses unleaded fuel has been increasing by about ten percent per year and is currently over fifty percent.[2] For a time, both the government and the petroleum industry expressed concern regarding the ability of the industry to convert gasoline production facilities to produce unleaded gasoline sufficient to meet the rapidly rising demand. A secondary concern was expressed by some as to the detrimental effect on total energy consumption of the higher crude input required per gallon of unleaded gasoline.

In retrospect, these concerns were exaggerated. Measures taken by the EPA to given refiners an incentive to produce unleaded gasoline, together with similar incentives created by the Department of Energy, resulted in an oversupply of unleaded gasoline. The results of our analysis of gasoline demand can illuminate the reasons for this situation.

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[1] These include a provision for relaxing the lead phase-down standard if a refiner increases unleaded gasoline production by a target amount.

[2] Motor Vehicle Manufacturers' Association, *Motor Vehicle Facts and Figures*, 1978-1980.

Table 3 compares the EIA Model forecasts of the composition of gasoline demand with actual data for 1978-1980. As originally supplied to IDA by the EIA, the model's predictions for unleaded gasoline demand were unreasonably high. An extensive examination of the model data and parameter values was performed to uncover the reasons for the high forecast. This examination revealed the following sources of error:

- The scrappage rates used to determine retirement of old automobiles were excessive; thus, the model was eliminating old cars which use leaded gasoline too rapidly.
- The assumption as to the number of trucks using unleaded gasoline was higher than available data indicate. The percentage was adjusted downward.
- The average number of miles driven in a car declines as the car ages. The parameter in the model which governs the rate of decline was estimated based on data from 1972. New data obtained in 1977 by the Nationwide Personal Transportation Study led to an upward revision of this parameter. This resulted in greater utilization of older cars relative to new ones. A consequence of this is a relatively greater use of leaded fuel.

As a consequence of these changes, the model predictions for fuel composition closely approximate the actual pattern.

Table 3 details these changes and their impact on predicted leaded and unleaded fuel demand. Columns (1) and (2) present the forecast before corrections were made. Note that the overprediction of unleaded gasoline use was associated with the underprediction of total gasoline usage; the model was substituting new high-mileage unleaded gasoline cars for older leaded models at too rapid a rate. Columns (3) through (5) incorporate the corrections and display percentages extremely close to the actual data for 1979 and the current DOE projection for 1980.

Table 3. IMPACT OF PRICE AND OTHER FACTORS ON GASOLINE DEMAND

Year	(1) Gasoline Price At 1978 Level		(2) Gasoline Price At Current Level		(3) Adjusted For New Car Sales		(4) Adjusted For Miles Per Gallon		(5) Adjusted For Utilization		(6) Actual Demand	
	Demand[a]	Percent Unleaded	Demand	Percent Unleaded	Demand	Percent Unleaded	Demand	Percent Unleaded	Demand	Percent Unleaded	Demand	Percent Unleaded
1978	7,354	36.3	7,350	36.3	7,507	33.4	7,503	33.3	7,425	33.2	7,412	34.0
1979	7,109	46.4	6,928	46.1	7,207	40.0	7,191	39.8	7,081	39.7	7,031	39.6
1980	6,814	54.6	6,350	53.7	6,715	46.1	6,677	45.5	6,659	45.5	6,610[b]	46.4[b]

[a]Gasoline demand in thousands of barrels per day.

[b]Current DoE/EIA projection for 1980.

Chapter VI

ELASTICITY OF GASOLINE DEMAND WITH RESPECT TO PRICE

The dramatic decline in gasoline consumption from 1978 to 1980 is a vivid reminder that American consumers do respond to price changes, even for an 'essential' consumption item such as gasoline. Economists have pointed out the dynamic nature of this adjustment process. In the short run, with the stock of vehicles fixed, the major way in which consumption can be reduced is through a reduction in vehicle miles travelled (this includes all measures which reduce vehicle miles including carpooling, switching to public transportation, etc.). Thus, a decrease in *vehicle* miles travelled (VTM) does not necessarily mean a decrease in *passenger* miles travelled by all transportation modes.

In the longer run, however, the consumer can diminish the effect of an increase in cost per gallon on his cost per mile travelled by substituting a vehicle with greater fuel efficiency. The increased miles per gallon of the new vehicle has the effect of *reducing* the cost per vehicle mile. Thus, after the initial decrease in VMT, utilization will slowly *increase*, although it is unlikely to reach its former level. This has important implications for emission standards. Since standards are set in terms of emissions per mile, not per gallon of gasoline consumed, high-mileage vehicles can emit more pollutants per gallon of gas consumed than can low-mileage vehicles. Since drivers of high-mileage vehicles have less financial incentive to curb their travel, total emissions might actually rise as the car fleet becomes more efficient.

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Table 4 shows how these results interact in the EIA Model. The left half of the table shows how the short-run and long-run effects of a change in price are reflected in gasoline consumption. In this exercise, the model was simulated assuming that the real price of gasoline stays fixed at its 1980 level. (Standard assumptions were made for other variables based on macroeconomic forecasts for GNP, Personal Income, and automobile prices.) In the base case, gasoline consumption declines until 1986, then rises slowly thereafter. The decline is attributable to increased purchasing of new fuel-efficient cars in response to the pre-1980 price increases. By 1986, the stock of vehicles is in equilibrium and rises with increases in income and GNP, while efficiency remains stable.

The second column of Table 4 shows a simulation in which the real gasoline price is increased ten percent in 1981 and maintained at the higher level. The higher gasoline price reduces consumption in every year of tne period. The initial short-run elasticity (Column 3) of -0.27 is basically achieved through decreased utilization. However, over time the elasticity rises as substitutions are made in the stock of vehicles. By 1991, the measured elasticity is -0.60 (a six percent decrease in consumption) which is associated with a 6.8 percent increase in fleet fuel efficiency. By this time vehicle miles would be only 1.3 percent lower than the base case.

The right half of Table 4 replicates this exercise, but with the assumption of constant real gasoline prices changed to one in which gasoline prices rise in real terms by five percent per year. The analysis reveals that the elasticity estimates are insensitive to this change in assumption. However, the increasing real price of gasoline caused gasoline consumption to decline throughout the period of forecast.

This analysis suggests that the impact of the 1978-80 price increase is still to come. The increase was 85 percent

Table 4. ELASTICITIES OF GASOLINE DEMAND
(Based on EIA/Sweeney Model)

	Constant Real Price Δ = 10 percent increase in 1981 price, maintained					Increasing Real Price (5 percent per year) Δ = 10 percent increase in 1981 price, maintained				
	Gasoline Demand					Gasoline Demand[d]				
Year	Base Case	After Increase	ηp.GAS[a]	ηUM[b]	ηMPG[c]	Base Case	After Increase	ηp.GAS	ηUM	ηMPG
1980	6,610	6,610	--	--	--	6,610	6,610	--	--	--
1981	6,047	5,883	-0.27	-0.26	-0.02	6,047	5,883	-0.27	-0.26	-0.02
1982	5,941	5,749	-0.32	-0.24	0.08	5,858	5,669	-0.32	-0.24	0.08
1983	5,898	5,680	-0.37	-0.22	0.17	5,717	5,508	-0.37	-0.22	0.16
1984	5,853	5,612	-0.41	-0.20	0.26	5,565	5,341	-0.40	-0.20	0.25
1985	5,875	5,610	-0.45	-0.19	0.35	5,465	5,227	-0.44	-0.19	0.33
1986	5,880	5,592	-0.49	-0.17	0.44	5,338	5,086	-0.47	-0.17	0.40
1987	5,952	5,640	-0.52	-0.16	0.52	5,260	4,996	-0.50	-0.16	0.47
1988	5,996	5,663	-0.56	-0.14	0.58	5,153	4,881	-0.53	-0.15	0.54
1989	6,127	5,774	-0.58	-0.13	0.63	5,114	4,832	-0.55	-0.14	0.59
1990	6,215	5,847	-0.59	-0.13	0.67	5,029	4,745	-0.56	-0.13	0.63
1991	6,288	5,909	-0.60	-0.13	0.68	4,930	4,647	-0.57	-0.13	0.66
1992	6,394	6,003	-0.61	-0.13	0.70	4,856	4,573	-0.58	-0.13	0.68
1993	6,563	6,159	-0.62	-0.13	0.70	4,827	4,545	-0.58	-0.13	0.68
1994	6,662	6,250	-0.62	-0.13	0.71	4,743	4,466	-0.58	-0.13	0.70
1995	6,755	6,336	-0.62	-0.13	0.71	4,660	4,386	-0.59	-0.13	0.70

[a] $\eta_{p.GAS}$ = elasticity of gasoline demand with respect to gasoline price.

[b] η_{UM} = elasticity of miles driven with respect to gasoline price.

[c] η_{MPG} = elasticity of average miles per gallon with respect to gasoline price.

[d] Gasoline demand is in thousands of barrels per day.

when measured in nominal dollars; this is equal to a real price increase of 60 percent, given the 25 percent increase in general inflation over the period. Even if there were no further increase in the real price of gasoline, substitution of high-mileage vehicles will ultimately reduce gasoline consumption by 36 percent, as compared with 1978 value. This would mean a consumption level of only 4.7 million barrels per day by 1990 if there were no increase due to growth in other determinants of demand. Even with these other factors included, demand is unlikely to exceed 5.5 million barrels per day.

Of course, nearly all of this figure would be unleaded gasoline. Currently, unleaded gasoline production runs around 3.1 million barrels per day.[1] Thus, continued investment in unleaded gasoline production facilities would appear to be required to meet the future demand. Whether the American Petroleum Industry can add capacity to meet the projected unleaded gasoline demand will depend upon both financial incentives for investment in these facilities and technical considerations related to the octane requirement for unleaded gasoline in tomorrow's cars. These questions are beyond the scope of this paper.

[1] *Weekly Petroleum Status Report, op. cit.*

APPENDIX A

DESCRIPTION OF THE EIA/SWEENEY MODEL

DESCRIPTION OF THE EIA/SWEENEY MODEL

The EIA/Sweeney Motor Gasoline Model is divided into three sections, each forecasting a different type of demand on a yearly basis. The types of demand are automobile, truck and a miscellaneous group consisting of bus usage, off-road usage, and evaporation losses.

The automobile section is by far the most sophisticated and thus will be described in more detail than the others. It is a stock-flow model, based on the premise that gasoline demand will change if people alter the number of miles they drive (flow), *or* if the average efficiency of the stock of automobiles which they drive changes. Vehicle miles is a relatively volatile component of demand, changing rapidly in response to driving costs. In the model it is estimated by a single equation (see Table A-1 for a list of equations and their variables.

On the other hand, fleet efficiency (average miles per gallon) changes slowly, since the great majority of the automobile stock carries over from one year to the next. People may decide to scrap inefficient old cars and buy only high-mileage new cars in response to an increase in gasoline prices, but typically the number of cars involved in these decisions will be small relative to the total. However, over several years the effect of such decisions becomes quite significant, so most of the automobile section is an attempt to predict changes in stock efficiency.

Table A-1. AUTO MODEL EQUATIONS

Dependent Variables	Independent Variables
New Passenger Car Registrations	Population, unemployment, average real gas price, effective stock per capita, disposable income, new car prices
Total Auto Vehicle Miles	Population, gas cost per mile, disposable income, per capita registrations, average hours worked per week
New Car On-Road Miles Per Gallon	Real gas price, auto efficiency factor (both lagged one year)
Survival Fractions	Cumulative average vehicle miles for the given model year in the given prediction year

Note: Some independent variables are (or need in their calculation) dependent variables of other equations. Model calculations are therefore recursive.

The smallest unit of stock prediction is the model year, or vintage. For each forecast year, the model's equations predict how many cars will be sold and the average miles per gallon of these new cars. Then the number of cars from each previous model year which are scrapped is estimated. This establishes the number of surviving cars for each vintage.

For the purpose of evaluating fleet efficiency, it is not possible to simply add up all surviving cars to arrive at the auto stock. Department of Transportation surveys have shown that older cars are driven, on the average, fewer miles than newer ones. The concept of an "effective" (or new equivalent) vehicle stock is used to circumvent this problem. Consider ten year old cars; imagine that in a given forecast year only 1,000 of the cars sold a decade before survive, and that they are driven half as many miles per year as new cars (5,000

miles per year as opposed to 10,000 miles per year). We would like to be able to assume that each of these older cars "drives" the same distance as a newer car. Since gasoline consumption is the important variable, this can be done by cutting the *number* of ten year old cars in half. In reality, the 1,000 real cars at 5,000 miles per year drive a total of 5 million miles; the total miles driven by the vintage cars is unchanged if 500 new equivalent cars are thought to drive 10,000 miles each. (They drive these miles at an average miles per gallon equal to that of their model year.)

This sort of scheme is necessary to ensure proper weighting of the total fleet average miles per gallon figure. If the number of ten year old cars were not adjusted, the ten year old miles per gallon figure would have more influence (twice as much) on the fleet miles per gallon estimate than is warranted by actual usage.

After the effective stock of each vintage year is calculated, a harmonic mean fleet miles per gallon is arrived at using the effective stocks as weights. This is then combined with the total vehicle miles estimate to produce the auto gasoline consumption prediction.

The overall efficiency with which miles are driven will change when usage patterns shift as well as when scrappage rates or new car miles per gallon change. The model is unfortunately not designed to allow the forecasting of such changes. The user may alter the pattern of miles driven by age of car if new data become available, but the model in its operation considers this pattern to be invariant over time. Likewise, the model would be unable to predict a shift from driving existing poor-mileage cars about the same distances as high-mileage cars (of the same vintage) to one where the high-mileage cars were favored. Both limitations were forced on Sweeney by a lack of data.

A number of user assumptions about data values are necessary. Aside from use of predictions concerning future macroeconomic data and gasoline prices, those of principal interest have to do with the division of total gasoline into leaded, unleaded, and diesel fuels.

The model allocates total fuel use among the three types by taking the ratio of the effective stock of users of a given type over the total effective stock and multiplying this times total demand. In order to do this, the numbers of cars using each fuel type in each vintage are determined according to fractions provided by the user. Accurate specification of these fractions is particularly difficult for the 1975-1979 vintages due to the lack of data on the number of new imported cars (and the number of new captive imports) that were leaded. Unfortunately, the accuracy of predictions of future demand for particular fuel types, as opposed to total demand, is somewhat dependent upon the user's estimates of these fractions.

A final assumption is that leaded and unleaded new cars from the same model year have the same average mpg. This is not very tenable for the last five years, but data are not available to allow more accurate specifications.

The truck section of the Sweeney Model is much less sophisticated, largely because usable data are not available in the same detail for trucks as for automobiles. To conform to FHWA data, trucks are divided into the categories of 'combination' and 'single-unit', which can be roughly thought of as semi-trailer trucks and all others (including pickups). Table A-2 shows the variables used in the equations of the truck section.

The model year as the basic unit of prediction and the effective stock concepts cannot be used. Instead, for each

Table A-2. TRUCK MODEL EQUATIONS

Dependent Variables	Independent Variables
Total Single Unit Registrations	Population, per capita GNP, lagged per capita registrations, real gas price, per capita vehicle miles
Total Single Unit Vehicle Miles	Unemployment, real gas price, disposable income
Average Single Unit Fleet Miles Per Gallon	Lagged fleet miles per gallon, price of gas, disposable income
Total Combination Registrations	Lagged per capita registrations, per capita vehicle miles, per capita GNP, real price of diesel fuel
Total Combination Vehicle Miles	Population, per capita GNP, unemployment, real price of diesel fuel
Average Combination Fleet Miles Per Gallon	Is constant

Note: Equations evaluated recursively.

forecast year, total registrations, total average miles per gallon and total vehicle miles are estimated for each category of truck. Gasoline consumption is calculated directly from these.

Again the user must provide the basis for the division of total consumption into leaded, unleaded, and diesel fuels; here it must be done by estimating the fraction of the total fleet (not just of a model year) that is accounted for by each type.

Table A-3 displays the variables used in the final section of the model, where non-highway use, bus demand, and evaporation losses are forecast. Again an assumption must be made regarding the distribution of the totals among the three fuel types.

Table A-3. MISCELLANEOUS EQUATIONS

Dependent Variables	Independent Variables
Non-Highway Fuel Use	Real GNP, population, real gas price, time (year)
Bus Fuel Use	Population, disposable income, time (year)
Evaporation Losses	Time (year)

The Sweeney Model is thus fairly complete in its treatment of the demand for motor fuel. It is plagued by difficulty in determining the shares of leaded, unleaded, and diesel fuels, and its accuracy is probably reduced somewhat by the unsophisticated nature of the truck and miscellaneous sections.

The model's strength lies in its auto section, which is not only intuitively appealing, but also allows the sensitivity of demand to many types of trends, both short and long term, to be explored. Because of the limited amount of data available, the specification of the other two sectors is simpler and less appealing. Fortunately, automobiles consume by far the largest share of motor fuel, so the model is quite useful in spite of the less detailed description of these other sectors.

IDA USE OF THE EIA/SWEENEY MODEL

In determining the reasons for overprediction of gasoline consumption and of unleaded gasoline consumption in particular, IDA was able to leave the structure of the model completely intact. Further, only one parameter required re-estimation. Most of the work involved correction of the input data and forcing some model estimates to conform to actual values.

This approach has not yielded a totally corrected model; new predictions for future years are only somewhat more reliable than the original ones. However, the approach does indicate areas where improvement is particularly desirable; it also highlights inherent limitations. A few comments on these matters will be made at the end of this appendix.

What follows is a description of the variables changed, with sources of new data noted and explanations of interpolation methods given where necessary. Table B-1 contains a list of the variables and their corrected values for relevant years. They are grouped below into parameters, inputs, and model predictions for convenience.

A. PARAMETERS

Only one coefficient used in the model was re-estimated. This is γ, which appears as a constant in the effective stock equation. The value of $(1 - \gamma)$ is the annual rate of decline in average vehicle usage. For each (i^{th}) year of prediction, this equation converts the number of cars from each (j^{th}) model year still in use into a smaller new equivalent number, based on a pattern of usage by age of car (see Appendix A for

Table B-1. CORRECTED VALUES FOR SELECTED VARIABLES

Variable Mnemonic	Description of Variable	Unit	Corrected Values			
			1977	1978	1979	1980
PGASL	Leaded Fuel Price	Current $	0.619[a]	0.645	0.870	1.250
PGASU	Unleaded Fuel Price	Current $	0.663[a]	0.691	0.917	1.290
PGASD	Diesel Fuel Price	Current $	0.567a	0.604	0.800	1.200
FRIM	Import Share of New Car Sales	Fraction	0.18[a]	0.20	0.22[a]	0.27
FRIL	Leaded-Using Fraction of New Imports	Fraction	0.420	0.500	0.580	0.050
FRID	Diesel-Using Fraction of New Imports	Fraction	0.005	0.006	0.150	0.016
FRDL	Leaded-Using Fraction of New Domestics	Fraction	0.0[a]	0.0[a]	0.0[a]	0.0[a]
FRDD	Diesel-Using Fraction of New Domestics	Fraction	0.0	0.004	0.014	0.018
FRSL	Leaded-Using Fraction Single-Unit Trucks	Fraction	0.84	0.78	0.72	0.67
FRSD	Diesel-Using Fraction Single-Unit Trucks	Fraction	0.01	0.01	0.02	0.02
NPCR	New Passenger Car Registrations	Millions	10.826[a]	10.946[a]	10.335	8.511
VRS	Total Single-Unit Truck Registrations	Millions	28.298	30.336	31.978	33.271
VRC	Total Combination Truck Registrations	Millions	1.264	1.367	1.442	1.530
MPG	Average New Car Fuel Efficiency	Miles/Gallon	15.19[a]	16.72	17.34	19.44
VMA	Total Miles Driven by Autos	Trillions	1.141[a]	1.215	1.186	1.149
VMS	Total Miles Driven by Single-Unit Trucks	Trillions	0.266[a]	0.260	0.256	0.255
VMC	Total Miles Driven by Combination Trucks	Trillions	0.064[a]	0.066	0.067	0.065
VMB	Total Miles Driven by Buses	Trillions	0.006[a]	0.006	0.006	0.006

[a]Original value not corrected.

a more intuitive description). The pattern is given by the following equation:

$$VM_{i,j} = VM_0 \cdot \gamma^{(i-j)} \qquad \text{(B1)}$$

where $VM_{i,j}$ is the average vehicle miles driven by cars of the j^{th} model year during the i^{th} calendar year, and VM_0 is equal to the number of miles a new car is driven.

The Department of Transportation occasionally collects data on average vehicle miles by age of car; these can be used to estimate γ based on a regression in log-linear form.[1] Gamma is then used in the effective stock equation

$$ES_{i,j} = R_{i,j} \cdot \gamma^{(i-j)} \qquad \text{(B2)}$$

where the $ES_{i,j}$ is the effective stock of each j^{th} model year in the i^{th} calendar year and the $R_{i,j}$ is the number of cars from each j^{th} model year registered in the i^{th} calendar year.

New data were available from the Department of Transportation (the surveys for the 1972 study were done in 1969; these data result from 1977 surveys).[2] Re-estimation of γ using these data resulted in a value of 0.9415, as opposed to the old value of 0.9210.[3]

This change has a significant impact on model results, especially on the leaded-unleaded fuel usage division. A

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[1] Federal Highway Administration, Department of Transportation, *Nationwide Personal Transportation Study*, Report #2, April 1972.

[2] Federal Highway Administration, Department of Transportation, *Nationwide Personal Transportation Study*, forthcoming.

[3] At the time of calculations, only preliminary data were available; these gave a value of 0.9406 for the new Gamma. The value of 0.9415, derived from final data obtained at the time of writing, was not judged different enough from 0.9406 to require recalculation of model results.

value of γ which is too low leads to an underestimation of old car usage and thus to an underestimation of the usage share of leaded gasoline.

B. CHANGES TO INPUT DATA VALUES

We found it necessary to change only four of the many inputs the Sweeney Model requires. There were (1) fuel prices, (2) the fraction of new car sales which were imports (not including captive imports), (3) the fractions of new cars which used leaded or diesel fuels, and (4) the fractions of all single-unit trucks which used leaded or diesel fuels.

1. Fuel Prices (PGAS)

Actual fuel prices were considerably higher than those predicted for 1980 and somewhat higher than predicitons for 1979 (the predictions appear to have been made in 1978 or early 1979). New values, taken from the Lundberg Letter, were substituted for 1979-80.[1] The 1980 figures represent price experience through June of this year.

2. Import Fractions (FRIM)

The import fraction was understated for 1978 and 1980; a correct value for 1978[2] and an estimate for 1980[3] were obtained.

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[1] "Lundberg Letter," Volumes VI, VII, (1979, 1980), various issues.

[2] J.D. Murrell, Foster, J.A., and Bristor, D.M., *Passenger Car and Light Truck Fuel Economy Trends Through 1980*, SAE Technical Paper #800-853, (1980), Table C-6.

[3] Motor Vehicle Manufacturers' Association, Washington Office, per a telephone conversation.

3. Import Fuel Use (FRL, FRD)

The most important fraction is of interest because the fractions of new cars which use leaded, unleaded, or diesel fuels are estimated separately for imports and domestic makers. These fractions are used in the allocation of total fuel consumption between the three fuel types.

The diesel fractions for 1977-80 (1979-80 are estimates) were directly obtainable.[1] However, good data concerning the leaded fractions are not available (given leaded and diesel, the unleaded fraction follows directly). An estimate was made based on Table C-6 of Murrell,[2] which shows that ten percent of the total new car fleet did not use catalytic converter technology in 1978, and two percent will not in 1980. For convenience we assumed that only imported new cars use leaded gasoline (some captive imports use it also, but no harm is done). We adjusted the leaded import fraction so that ten percent of the total new fleet was leaded in 1978, somewhat less in 1977 (eight percent), and somewhat more in 1979 (13 percent). Only one and one-half percent of new cars are taken to be leaded in 1980.

These estimates are probably somewhat high, since apparently some cars are certified "unleaded only" even if they do not use catalytic converters.

4. Truck Fuel Use (FRSL, FRSD)

The fractions of single-unit trucks (non-semi-trailer trucks, roughly) which are leaded or diesel users must be specified for the entire single-unit fleet in each year, not just for each year's new trucks. The fractions for each year

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[1] J.D. Murrell, *et al.*, Table C-5-14.

[2] *Idem.*, Table C-6.

are the sole determinant of how that year's total single-unit fuel consumption is allocated between the three fuel types.

No data are available which will allow direct specification of the fractions. Estimations were made using two tables from *Motor Vehicle Facts and Figures,* one showing truck sales by weight and body type, the other trucks in use by age.[1]

At the outset it was necessary to estimate the percentage of sales of each body type in each relevant weight class that used unleaded gasoline. The percentages were assumed constant over the 1975-1980 model years, except for changes made in those for the six to ten thousand pound class for 1979-80 (changes were necessary because of the increased weight limit for regulatory purposes in those years). This allowed a percentage of new truck sales which were unleaded gasoline users to be developed for each model year; each year's estimate of the unleaded percentage of the total truck fleet was made by combining the model year estimates with the fraction of the fleet accounted for by a given model year (from the average age table). Finally, this was converted into a fraction of the single-unit fleet (fairly straightforward, since no combination trucks are unleaded gasoline users).

Data were not available for 1980, so it was assumed that the fairly constant growth in the unleaded share of five to six percent per year would continue.

This is clearly an uncertain method of arriving at the estimates. The unleaded percentages of each body type and weight class (on which the process is based) are really off the cuff guesses, though tempered by discussions with government industry sources. However, those same sources offered

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[1] Motor Vehicle Manufacturers' Association, *Motor Vehicle Facts and Figures,* 1976-1980.

no hope of a better method; further, it was found that the original estimates used in the model were made on a much less systematic basis.

C. PREDICTIONS

The tables of Appendix A show the variables found in a number of equations which the model uses to estimate quantities necessary to the prediction of fuel consumption. In addition to evaluating the impact of correcting inputs to the model, we also wished to evaluate the effect on consumption predictions of replacing these "intermediate" estimates with correct values. This can be done by bypassing the equations in relevant prediction years and inserting the correct values. We did this for auto and truck registrations, auto scrappage, new car fuel efficiency, and auto, truck, and bus usage (vehicle miles).

1. New Car Registrations (NPCR, VRS, VRC)

The new passenger car registrations equation was accurate for 1978; for 1979 a correction was obtained, and for 1980 an estimate was made based upon sales figures through June.[1]

Truck registrations data were more difficult to obtain; there are a number of measures which are not identical. The Sweeney Model is based on FHWA measures, which were available for 1978[2] but not for 1979-80. We computed a 1979 estimate by multiplying the correct 1978 figure by growth rates in light and medium (taken as roughly equivalent to single unit)

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[1] Motor Vehicle Manufacturers' Association, Washington Office, per telephone conversation.

[2] Federal Highway Administration, Department of Transportation, *Highway Statistics*, Tables VM-1, VM-2, 1978.

and heavy (combination) truck registrations as reported by MVMA.[1] No data were available for 1980.

2. Scrappage of Vehicles (SU)

The Sweeney Model uses a variant of the scrappage concept known as "survival fractions." These are the fraction of a model year still in use in a given year, compared to the largest number ever registered. Table B-2 contains the model-estimated and correct sequences for 1978-80.[2] Data are not available for 1980, so those fractions were arbitrarily set equal to the 1979 sequence (except for the 1974-76 model years, which were adjusted to reflect the poor survival of 1975 cars).

3. Fuel Efficiency (MPG)

Correct average new car miles per gallon ratings were obtained in EPA form.[3] These were converted to on-road ratings through use of EPA-developed deflators.[4]

4. Vehicle Miles Travelled (VM)

The model's vehicle usage estimates are compatible with those found in *Highway Statistics*.[5] Unfortunately, data in this form are available only through 1978. The 1979 and 1980 corrections were produced in the following manner: the 1978-

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[1] Motor Vehicle Manufacturers' Association, *Motor Vehicle Facts and Figures, 1980*.

[2] Survival fractions are easily calculated from the "Cars in Use by Age" table of *Motor Vehicle Facts and Figures*, 1978-1980.

[3] For 1978-79, the source was Murrell, Foster, and Bristor, *op. cit.*, Table C-2. For 1980, an estimate was obtained verbally from MVMA's Washington Office.

[4] J.D. Murrell, *Passenger Car Fuel Economy: EPA and Road; A Report to the Congress*, EPA Report No. EPA-46013-80-010, 1980.

[5] Federal Highway Administration, *op. cit.*

Table B-2. SURVIVAL FRACTIONS (PREDICTION)

Model Year	1978		1979		1980	
	Original	Correct	Original	Correct	Original	Estimated
1979					1.000	1.000
78			1.000	1.000	.996	.994
77	1.000	1.000	.995	.994	.985	.963
76	.995	.992	.981	.963	.960	.943
75	.901	.949	.768	.910	.625	.800
74	.954	.966	.898	.922	.815	.879
73	.906	.932	.815	.879	.678	.830
72	.880	.900	.773	.830	.606	.737
71	.777	.822	.616	.737	.416	.665
70	.705	.763	.533	.665	.335	.541
69	.587	.655	.412	.541	.236	.448
68	.485	.551	.325	.448	.177	.352
67	.379	.442	.245	.352	.126	.278
66	.295	.349	.185	.278	.093	.209
65	.217	.265	.142	.209	.072	.158
64	.170	.200	.108	.158		
63	.117	.142				

1979 percent change in vehicle miles as shown in *Traffic Volume Trends*[1] was applied to the correct 1978 total miles figure to produce a 1979 total miles estimate. In turn, a percent change between the January-April 1979 and January-April 1980 periods was applied to this to obtain a 1980 total miles estimate. These totals were then split into auto, truck, and bus miles in the proportions suggested by the model estimates,

[1] Federal Highway Administration, Department of Transportation, *Traffic Volume Trends*, December 1979 and April 1980.

since these take economic activity, registrations, etc., into account.

D. CONCLUDING REMARKS

Though we corrected many of its predictions, the model in general does not do badly in its forecasting of registrations, usage, etc., once its inputs, particularly prices, are corrected. There is room for improvement in all the equations, especially in those related to scrappage; but without reasonably accurate fuel price predictions, none of the equations will produce accurate results. This is not a limitation of the Sweeney Model alone; anv long-term prediction of fuel consumption must be looked at with a good deal of skepticism until fuel prices become more predictable.

COMPARISON OF EIA/SWEENEY AND WHARTON MODEL RESULTS

Because the Wharton Model differs both in design and intended use from the EIA/Sweeney Model, only a few variables can be directly compared. Fortunately these are the ones of greatest interest in this study: gasoline consumption, vehicle miles, vintage and fleet efficiency (on-road miles per gallon), and new car and total registrations. The nominal values for each variable along with percentage changes between years are set out in the attached tables.

It should be noted that the EIA/Sweeney and Wharton predictions for total registrations and miles per gallon do not measure exactly the same variables, so comparisons should be made with care. Results for each of the variables are presented below. A final section links miles per gallon, vehicle miles, and registrations behavior to that of the gas measure.

Note that only the automobile section from the EIA/Sweeney Model was used since the Wharton Model does not deal with trucks or other gasoline consumers; note also that the comments focus on 1978-1980.

A. VEHICLE MILES

Table C-1 shows the predictions for vehicle miles driven. The nominal figures from the two models are extremely close for 1978 and 1979; for 1980 the EIA/Sweeney Model predicts a 2.2 percent larger decrease, leading to some divergence in the predictions.

Table C-1. VEHICLE MILES DRIVEN (AUTOMOBILES ONLY)

Year	Miles (billions)			Annual Percent Change		
	EIA/Sweeney	Wharton	Difference	EIA/Sweeney	Wharton	Difference
1978	1,206	1,206	0	5.7	7.2	1.5
1979	1,157	1,155	-2	-4.1	-4.2	0.1
1980	1,076	1,099	23	-7.0	-4.8	-2.2
1981	1,048	1,083	35	-2.6	-1.5	-1.1
1985	1,072	1,151	21	2.3[a]	6.3[a]	4.0[a]

[a]1981-1985 rate of change.

B. GASOLINE CONSUMPTION

Table C-2 displays the models' forecasts for automobile gasoline demand. The EIA/Sweeney Model consistently predicts less gasoline usage for 1978 through 1980, on the order of two to 2.25 billion gallons. This is almost certainly due to a relatively constant difference between the two models' estimates of fleet miles per gallon. The percentage changes in consumption predicted by the two models are fairly similar, but the EIA/Sweeney Model predicts larger decreases in consumption over time. This eventually forces the difference between the two forecasts out of the two billion gallon range.

C. REGISTRATIONS

The EIA/Sweeney Model consistently predicts more new car registrations for 1978-1980 than does the Wharton Model, as Table C-3 shows. The difference is small in 1978 but is over ten percent in 1980, and over 20 percent in 1981. The models seem to differ fundamentally in their predictions--the EIA/Sweeney Model's forecasts show a sharp drop in 1980 with an immediate recovery in 1981; while the Wharton Model results

Table C-2. COMPARISON OF IDA AND WHARTON GASOLINE DEMAND MODELS (BASE CASE)

Year	Gallons (billions)			Annual Percent Change		
	IDA	Wharton	Difference	IDA	Wharton	Difference
1978	82.19	84.49	2.30	1.87	3.9	2.03
1979	76.98	78.86	1.88	-6.34	-6.66	0.32
1980	69.89	72.40	2.51	-9.21	-8.19	-1.02
1981	64.91	68.35	3.44	-7.13	-5.59	-1.54
1985	52.99	61.42	8.43	-18.36[a]	-10.14[a]	-8.22

[a]1981-1985 rate of change.

Note: Percent changes listed for 1985 are for 1981-1985. The sign on differences is with reference to IDA--a negative means the Wharton value is *less*.

Table C-3. AUTOMOBILE REGISTRATIONS

Year	New Cars						Total					
	Number (millions)			Annual Percent Change			Number (millions)			Annual Percent Change		
	IDA	Wharton	Difference	IDA	Wharton	Difference	IDA	Wharton	Difference	IDA	Wharton	Difference
1978	10.95	10.90	-0.05	1.11	1.00	-0.11	121.6	102.5	-19.1	2.4	2.2	-0.2
1979	10.81	10.47	-0.34	-1.28	-3.94	2.66	118.6	105.2	-13.4	-2.5	2.6	5.1[b]
1980	9.60	8.73	-0.87	-11.19	-16.62	5.43	114.3	107.3	-7.0	-3.6	2.0	5.6[b]
1981	10.60	8.45	-2.15	10.42	-3.21	13.63	111.7	108.4	-3.3	-2.3	1.0	3.3[b]
1985	10.65	10.49	-0.16	0.47[a]	24.14[a]	23.67[a]	114.7	113.0	-1.7	2.7[a]	4.2[a]	1.5[a]

[a]1981-1985 rate of change.

[b]Indicates that percent changes are occurring in opposite directions, so the sign is not based on an absolute value difference.

indicate an even sharper 1980 drop, followed by lean years for the auto industry in 1981 and 1982 with a gradual recovery to essential equivalence to the EIA/Sweeney Model predictions by 1985.

In light of this, the figures for total registrations are quite surprising. The EIA/Sweeney Model predicts a steady decrease in the number of cars through 1983, with a recovery to 1980 levels by 1985; while the Wharton Model predicts a slow but steady increase through 1985. It must be pointed out that the nominal values are almost certainly not themselves comparable, since the EIA/Sweeney Model outputs total registrations, while the Wharton Model uses a variable called "Cars in Operation." However, this does not seem adequate to explain the difference in trend; the two models must be making different scrappage predictions. Unfortunately, the EIA/Sweeney Model does not output scrappage information in a form comparable to the Wharton Model.

D. MILES PER GALLON (MPG)

Table C-4 displays the fuel efficiency predictions of the two models. For 1978-1980, the figures do not diverge too much; the Wharton Model's estimate is consistently less by zero to two miles per gallon for new cars, and 0.2 to 0.4 miles per gallon for the fleet as a whole. However, the trends are different. The EIA/Sweeney Model predicts small efficiency increases in 1979 and 1980, followed by a huge jump in 1981 and steady large increases thereafter (for new cars). In contrast, the Wharton Model predicts a large jump in 1979 followed by steady large increases.

These trends are reflected in the total fleet efficiency estimates; the Wharton Model has fleet efficiency increasing at a somewhat faster rate until 1981, when the EIA/Sweeney Model-estimated rate of increase speeds up considerably.

Table C-4. FUEL EFFICIENCY (MILES PER GALLON)

Year	New Car Miles Per Gallon (Average)						Total Fleet Miles Per Gallon (Average)					
	On-Road Miles Per Gallon			Annual Percent Change			On-Road Miles Per Gallon			Annual Percent Change		
	IDA	Wharton	Difference	IDA	Wharton	Difference	IDA	Wharton	Difference	IDA	Wharton	Difference
1978	16.42	14.62	-1.80	8.10	8.40	0.30	14.68	14.27	-0.41	--	--	--
1979	16.72	16.10	-0.62	1.83	10.12	8.29	15.03	14.65	-0.38	2.38	2.66	0.28
1980	17.03	16.85	-0.18	1.85	4.66	2.81	15.39	15.18	-0.21	2.40	3.62	1.22
1981	20.27	17.64	-2.63	19.03	4.69	-14.34	16.15	15.84	-0.31	4.94	4.35	-0.59
1985	26.45	20.81	-5.64	30.49	17.97	-12.52	20.24	18.75	-1.49	25.33	18.37	-6.96

E. LINKAGES

Both the initial difference between the nominal gasoline consumption estimates of the two models and the increase in the EIA/Sweeney rate of decline of consumption can be explained by reference to the vehicle miles and fleet miles per gallon figures. The EIA/Sweeney Model predicts a faster rate of decline in vehicle miles, while the fleet miles per gallon estimates increase at similar rates; therefore, the vehicle miles predictions are responsible for the differing rates of change of consumption. As noted above, the relatively constant difference between fleet miles per gallon estimates is sufficient to explain the relatively constant differences between gas consumption estimates that is especially evident during the first few years.

Looking behind vehicle miles at registration figures, it can be seen that the EIA/Sweeney Model estimate of a declining vehicle stock compared to the Wharton Model estimate of an increasing one is probably at least partly responsible for the divergence in vehicle miles estimates (different estimates of stock utilization might also be responsible, of course). Since new car registrations estimates do not explain the differing stock figures, the importance of scrappage rates as a factor in the gasoline consumption estimates is pointed out.